

# Generative Artificial Intelligence: A Primer

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## ABSTRACT

Artificial Intelligence (AI) is increasingly a part of our world and it is rapidly changing our lives. Generative AI (GenAI) is a subset of artificial intelligence that uses generative models to produce text, images, videos, or other forms of data. It is essentially a narrow type and application of the broader artificial intelligence umbrella of technologies. It describes algorithms (such as ChatGPT) that can be used to create new content, including audio, code, images, text, simulations, and videos. It is specifically designed and trained to generate new content. The versatility and potential of GenAI to transform various aspects of business operations make it an attractive investment for companies across industries. This paper provides an introduction to generative AI.

**KEYWORDS:** *artificial intelligence, AI, general artificial intelligence, GenAI*

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## INTRODUCTION:

Artificial intelligence is the practice of getting machines to mimic human intelligence to perform tasks. It is any technology that can perform tasks that usually require a human brain [1]. It seems possible that within the next few years, anything in the technology, media, and telecommunications not connected to AI will be considered obsolete or ineffective. Generative AI has been a breakthrough. It refers to the use of AI to create new content, like text, images, music, audio, and videos. It can learn human language, programming languages, art, chemistry, biology, or any complex subject matter. It reuses what it knows to solve new problems.

Generative AI (GenAI) is a term for any type of AI system capable of using generative models to create new forms of humanlike creative content, like text, images, music, audio, video and more. GenAI models include various algorithms able to learn the various patterns and structures of input training data before generating novel outputs with similar characteristics. In the United States, a group of companies including OpenAI, Alphabet, and Meta signed a voluntary

agreement with the Biden administration in July 2023 to watermark AI-generated content.

## WHAT IS ARTIFICIAL INTELLIGENCE?

The term “artificial intelligence” (AI) is an umbrella term John McCarthy, a computer scientist, coined in 1955 and defined as “the science and engineering of intelligent machines.” It refers to the ability of a computer system to perform human tasks (such as thinking and learning) that usually can only be accomplished using human intelligence [2]. Typically, AI systems demonstrate at least some of the following human behaviors: planning, learning, reasoning, problem solving, knowledge representation, perception, speech recognition, decision-making, language translation, motion, manipulation, intelligence, and creativity. AI symbol is shown in Figure 1 [3].

The 10 U.S. Code § 2358 define artificial intelligence as [4]:

1. “Any artificial system that performs tasks under varying and unpredictable circumstances without significant human oversight, or that can learn

from experience and improve performance when exposed to data sets.

2. An artificial system developed in computer software, physical hardware, or other context that solves tasks requiring human-like perception, cognition, planning, learning, communication, or physical action.
3. An artificial system designed to think or act like a human, including cognitive architectures and neural networks.
4. A set of techniques, including machine learning, that is designed to approximate a cognitive task.
5. An artificial system designed to act rationally, including an intelligent software agent or embodied robot that achieves goals using perception, planning, reasoning, learning, communicating, decision making, and acting.”

AI provides tools creating intelligent machines which can behave like humans, think like humans, and make decisions like humans. The main goals of artificial intelligence are [5]:

1. Replicate human intelligence
2. Solve knowledge-intensive tasks
3. Make an intelligent connection of perception and action
4. Build a machine which can perform tasks that requires human intelligence
5. Create some system which can exhibit intelligent behavior, learn new things by itself, demonstrate, explain, and can advise to its user.

AI is not a single technology but a range of computational models and algorithms. The concept of AI is an umbrella term that encompasses many different technologies. AI is not a single technology but a collection of techniques that enables computer systems to perform tasks that would otherwise require human intelligence. The major disciplines in AI include [6]:

- *Expert systems*
- *Fuzzy logic*
- *Neural networks*
- *Machine learning (ML)*
- *Deep learning*
- *Natural Language Processors (NLP)*
- *Robots*

These computer-based tools or technologies have been used to achieve AI's goals. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. Figure 2 shows a typical expert system, while Figure

3 illustrates the AI tools. These tools are gaining momentum across every industry. Analytics can be considered a core AI capability.

## CONCEPT OF GENERATIVE ARTIFICIAL INTELLIGENCE

Generative AI (GenAI) is a type of artificial intelligence technology that can produce various types of content, including text, imagery, audio and synthetic data. It enables users to quickly generate new content based on a variety of inputs. GenAI uses neural networks, machine learning, deep learning models, complex algorithms, and large and varied training datasets to produce original content based on user input and how to reason in ways akin to a human brain. The technology is built on AI tools shown in Figure 4 [7]. It uses neural networks to identify the patterns and structures within existing data to generate new and original content.

The technology was introduced in the 1960s in chatbots. Joseph Weizenbaum created the first generative AI in the 1960s as part of the Eliza chatbot. Generative AI starts with a prompt that could be in the form of a text, an image, a video, a design, musical notes, or any input that the AI system can process. Various AI algorithms then return new content in response to the prompt. Figure 5 shows the symbol of generative AI [8].

The massive popularity of ChatGPT, perhaps the most successful proof of concept in technological history, has pushed GenAI enablement to the forefront of digital transformation discussions. Generative AI tools like ChatGPT (the GPT stands for generative pretrained transformer) have the potential to change how a range of jobs are performed. Rooted in 1960s chatbots, the game-changer came in 2014 with generative adversarial networks (GANs), enabling authentic replication of real individuals. OpenAI, the organization behind ChatGPT, released the model for testing by the general public in November 2022 [7]. Since ChatGPT burst on the scene in November 2022, generative AI (gen AI) has come a long way. While many have reacted to ChatGPT with fear, AI and machine learning clearly have the potential for good [9].

Generative models are at the core of generative AI. These models learn patterns, structures, and representations from existing data and then generate new samples that align with the learned characteristics. These include algorithms like Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and Transformer-based models (like GPT). Figure 6 shows different types of GenAI models [10].

Generative AI can be thought of as a machine-learning model that is trained to create new data, rather than making a prediction about a specific dataset. Since its inception, the field of machine learning used both discriminative models and generative models, to model and predict data. A generative AI system is constructed by applying unsupervised machine learning or self-supervised machine learning to a data set. The most common way to train a generative AI model is to use supervised learning. Generative AI can also be trained on the motions of a robotic system to generate new trajectories for motion planning or navigation. Generative AI models are used to power chatbot products such as ChatGPT.

The goal of generative AI is twofold [8]. First, to autonomously create meaningful and valuable content like art, music, or text, imitating human-like creativity. Second, it aims to push the boundaries of what machines can achieve creatively and productively. Examples of generative AI tools include generative AI chatbots, such as ChatGPT, Gemini, and Claude, that can provide logical and contextualized responses to complex user queries.

Here are some of the limitations to consider when implementing or using a generative AI app [11]:

- It does not always identify the source of content.
- It can be challenging to assess the bias of original sources.
- Realistic-sounding content makes it harder to identify inaccurate information.
- It can be difficult to understand how to tune for new circumstances.
- Results can gloss over bias, prejudice, and hatred.

## APPLICATIONS OF GENERATIVE ARTIFICIAL INTELLIGENCE

Generative AI has uses across a wide range of industries, including software development, healthcare, finance, entertainment, customer service, sales and marketing, art, writing, fashion, and product design. Producing high-quality visual art is a prominent application of generative AI. The generative AI model needs to be trained for a particular use case. Some applications of GenAI are shown in Figure 7 [10]. Generative AI has several use cases across industries such as finance, healthcare, manufacturing, telecommunication, and media and entertainment [3,9,12,13]:

- *Creating Images:* The first use cases for generative AI typically involved creating text and images, Generative AI has also been used to create new digital artist personalities AI-

generated media can take a person in an existing image or video and replace them with someone else's likeness using artificial neural networks. Figure 8 shows an image created using generative AI [14].

- *Writing:* Generative AI tools can produce a wide variety of credible writing in seconds, then respond to criticism to make the writing more fit for purpose. Any organization that needs to produce clear written materials potentially stands to benefit. For example, if you need to prepare slides according to a specific style, you could ask the model to “learn” how headlines are normally written based on the data in the slides, then feed it slide data and ask it to write appropriate headlines.
- *Finance:* Financial services companies use generative AI tools to serve their customers better while reducing costs. Financial institutions use chatbots to generate product recommendations and respond to customer inquiries, which improves overall customer service. Generative AI models can generate new financial data or conduct automated financial analysis tasks. One example is the Variational Autoencoder model, which can create artificial financial data to train machine learning models for financial analysis.
- *Coding:* Generative AI also can disrupt the software development industry by automating manual coding work. GenAI tools make it easy for anyone to generate computer code with very little technical knowledge. Whether you are a new developer or an experienced coder looking to work through complex problems, generative AI tools are quickly becoming accurate coders, especially for code completion and quality assurance tasks. This can also be incredibly helpful for product and app development when scalable, repeatable code production on a timeline can be difficult for human task forces.
- *Healthcare:* Generative AI has greatly benefited the healthcare sector, from medication discovery to imaging. In the process of finding new medications, generated models can suggest novel molecular architectures. These models aid in the construction, improvement, and prediction of diseases in medical imaging. When there is a dearth of real-world data, it is imperative to produce synthetic data. Generative AI enables early identification of potential disease to create effective treatments while the disease is still in an initial stage. Healthcare professionals can use generative AI to create personalized patient plans based on their medical history, genetic makeup,



and personal preferences. For example, AI computes different angles of an x-ray image to visualize the possible expansion of the tumor. As another example, AI scrutinizes medical records, symptoms, and images, to aid medical professionals in accurately diagnosing illnesses. Generative AI can be incredibly helpful for neurodivergent professionals in a variety of ways. It can assist with tasks that may be challenging for neurodivergent people, such as organizing and scheduling, by providing personalized and efficient solutions.

- *Marketing:* You can leverage generative AI for marketing and sales campaigns to create personalized content without compromising users' privacy. For example, Markov chain models can analyze past purchase histories to provide product recommendations customized to each customer's preferences. Not only does this increase sales, but it also enhances customer satisfaction.
- *Manufacturing:* The manufacturing industry can benefit from machine learning models to enhance production processes and create product designs. One such machine learning model is the Convolutional Neural Network(CNN), which can produce new 3D designs by examining existing ones.
- *Entertainment:* There are powerful generative AI tools that media houses and entertainment companies use to generate original content automatically. One of the more popular tools is the Recurrent Neural Network (RNN). It is a powerful technology for creating new music by analyzing existing musical patterns. Additionally, generative models can produce fresh video game content, including levels and characters, and generate new video content for streaming platforms.
- *Audio:* Generative AI tools can create human-like voices (voice synthesis), allowing computers to speak words that have never before been uttered by a human, as well as music and sound effects.
- *Video:* GenAI tools are beginning to emerge that allow us to create and edit video simply by describing what we want to see.
- *Synthetic Data:* The development of synthetic data through generative models is perhaps one of the most impactful solutions for overcoming the data challenges of many enterprises. It spans all modalities and use cases and is possible through a process called label efficient learning. Generative AI models can reduce labeling costs by either

automatically producing additional augmented training data or by learning an internal representation of the data that facilitates training AI models with less labeled data. Generative AI makes it easy to create entirely synthetic data sets for use in training other AI models that follow real-world rules without conferring privacy and data security obligations on those who store and use it.

- *Virtual Environments:* Think of virtual reality (VR) environments or video game worlds that can be explored and interacted with, or the rather hyped-up concept of the metaverse. Designing these is a highly complex task that can be greatly accelerated with the help of generative AI.
- *Language Translation:* GenAI facilitates seamless communication across languages by automatically translating text, which fosters global interactions.

## BENEFITS

The adoption of generative AI tools led to an explosion of AI-generated content across multiple domains. Different organizations have raced to incorporate GenAI tools into their business models. What makes generative AI different and special is that it puts the power of machine intelligence in the hands of just about anyone. Generative AI has the potential to replace a variety of jobs. Some of the key benefits of generative AI include [15,16]:

- *Operational Efficiencies:* Generative AI algorithms can be used to improve the efficiency and accuracy of existing AI systems, such as natural language processing and computer vision. Generative AI assistants and copilots are great at assisting users with routine tasks that can take up a lot of time. Some of the work that AI can now help with includes taking and summarizing meeting notes. With AI handling some of these types of tasks, employees have more time to focus on more strategic tasks for the business.
- *Scalable Content Generation:* When generative AI chatbots and models are given clear instructions for content generation, the initial drafts they produce are often close to human quality and take a fraction of the time. For example, ChatGPT can draft a 2,000-word article on a complex topic in less than a minute.
- *Increasing Productivity:* Generative AI excels in enhancing productivity, and accelerating manual or repetitive tasks. From automating email composition and coding to summarizing complex documents, its role in streamlining these

operations significantly contributes to overall operational efficiency.

- *Personalizing Experiences:* Generative AI stands out in tailoring content and information to specific target audiences. Whether developing chatbots for personalized user interactions or devising targeted marketing strategies based on the nuanced behavioral trends of individual customers, the technology proves invaluable in crafting personalized and engaging experiences.
- *Collaborative and Creative Tools:* Generative AI is positioned to play a pivotal role in shaping collaborative and creative tools. The vision is to create an interactive and collaborative ecosystem where generative technologies complement human creativity, serving as catalysts for innovation.
- *Automation:* Generative AI algorithms can help automate and accelerate a variety of tasks and processes, saving time and resources for businesses and organizations. Generative AI enables attended or semi-attended automation in various business workflows. For example, you can automatically compose an email by feeding the AI with previous customer replies. Human resource (HR) management involves regular performance reviews, where managers provide employees with personalized recommendations and development plans. Now, generative AI is stepping up as a capable assistant for HR managers. For example, Plai, an online HR management solution, uses generative AI to provide recommendations and suggest follow-up actions based on individual feedback.

## CHALLENGES

Generative AI has enormous potential for good and evil at scale. The development of generative AI has raised concerns from governments, businesses, and individuals, resulting in protests, legal actions, calls to pause AI experiments, and actions by multiple governments. To leverage AI for a more equitable society, proactive steps encompass mitigating biases, advocating transparency, respecting privacy and consent, and embracing diverse teams and ethical considerations. Concerns surrounding generative AI include environmental impact, ethical issues with data sourcing and plagiarism, data security and misuse issues, deepfakes and otherwise harmful content, and the replacement of human workers with AI tools. Other challenges include the following [12,14]:

- *Security:* AI privacy issues and AI cybersecurity concerns are at the forefront of generative AI. Data privacy and security concerns

arise if proprietary data is used to customize generative AI models. Efforts must be made to ensure that the generative AI tools generate responses that limit unauthorized access to proprietary data. Security concerns also arise if there is a lack of accountability and transparency in how AI models make decisions.

- *Biased Content:* Despite their promise, the new generative AI tools raise some ethical issues that likely will take years to sort out. Sometimes the information generative AI generates is just plain wrong or biased because it is built on the gender, racial, and myriad other biases of the Internet and society more generally and can be manipulated to enable unethical or criminal activity.
- *Misuse:* Concerns have been raised about the potential misuse of generative AI such as cybercrime, the use of fake news to deceive or manipulate people, and the mass replacement of human jobs. Intellectual property law concerns also exist around generative models that are trained on and emulate copyrighted works of art. Recent research has revealed that generative AI has weaknesses that can be manipulated by criminals to extract harmful information bypassing ethical safeguards. Cybergangs and other criminals have already begun to use generative AI to produce highly convincing documents, software, and images that become part of social engineering campaigns.
- *Risks:* The convincing realism of generative AI content introduces a new set of AI risks. There is the fear that AI will eventually become autonomous. Organizations that rely on generative AI models should reckon with reputational and legal risks involved in unintentionally publishing biased, offensive, or copyrighted content.
- *Copyright Protection:* There is a concern whether AI-generated works can qualify for copyright protection. The United States Copyright Office has ruled that works created by artificial intelligence without any human input cannot be copyrighted, because they lack human authorship. However, the office has also begun taking public input to determine if these rules need to be refined for generative AI.
- *Job Loss:* The intersection of AI and employment concerns among underrepresented groups globally remains a critical facet. While AI promises efficiency enhancements and skill acquisition, concerns about job displacement and biased recruiting processes persist among these groups.

For example, in April 2023, it was reported that image generation AI has resulted in 70% of the jobs for video game illustrators in China being lost.

- *Environmental Impact:* The overall impact of generative AI on the workforce and society at large is prompting serious discussion. Scientists and journalists have expressed concerns about the environmental impact that the development and deployment of generative models are having. This includes high CO2 emissions, large amounts of freshwater used for data centers, and high amounts of electricity usage. There is also concern that these impacts may increase as these models are incorporated into widely used search engines such as Google Search and Bing.
- *Sampling Speed:* In order to be used in content development workflows, many interactive apps, including real-time image editing, need to be generated quickly. Due to the scale of generative models, their slow sampling speeds have become increasingly apparent. There may be latency present in the time it takes to generate an instance. Particularly for interactive use cases such as chatbots, AI voice assistants, or customer service applications, conversations must happen immediately and accurately.
- *Creativity:* While generative AI can produce creative content, it often lacks true originality. The creativity of AI is bounded by the data it has been trained on, leading to outputs that may feel repetitive or derivative. Human creativity remains challenging for AI to replicate fully.
- *Cost:* Training and running generative AI models require substantial computational resources. Cloud-based generative AI models are more accessible and affordable than trying to build new models from scratch. Developing a generative AI model is so resource intensive that it is out of the question for all but the biggest and best-resourced companies.
- *Explainability:* Due to their complex nature, generative AI models are often considered black boxes. Understanding how these models arrive at specific outputs is challenging. Improving interpretability and transparency is essential to increase trust and adoption.

## CONCLUSION

Generative AI tools are a type of machine learning model that aims to produce new content from the data they have been trained on. They allow computers to create new and exciting content automatically. The impact of generative models is wide-reaching, and its

applications are only growing. These systems seem to be finding their way into practically every application imaginable.

Some AI proponents believe that generative AI is an essential step toward general-purpose AI. ChatGPT's ability to generate humanlike text has sparked widespread curiosity about generative AI's potential. Generative AI will continue to evolve, making advancements in translation, drug discovery, anomaly detection, and the generation of new content, from text and video to fashion design and music.

What the impact of generative AI will be in the future is hard to say. In the future, generative AI models will be extended to support 3D modeling, product design, drug development, digital twins, supply chains, and business processes. The horizon of generative AI is laden with promising prospects, set to redefine technological landscapes and societal paradigms. More information generative AI can be found in the books in [17-20].

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Figure 1 AI symbol [3].

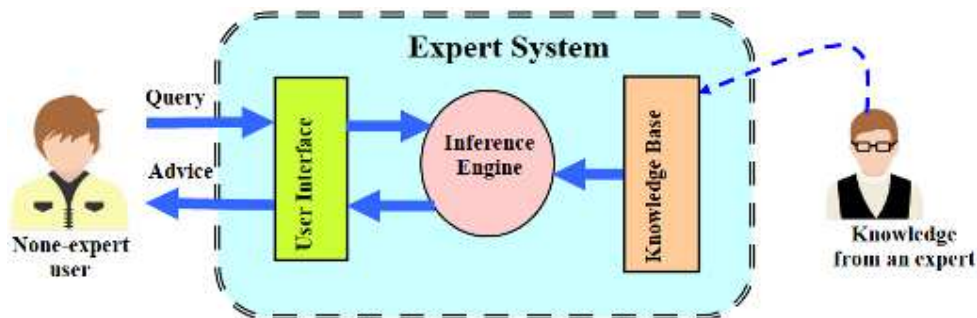


Figure 2 A typical expert system.

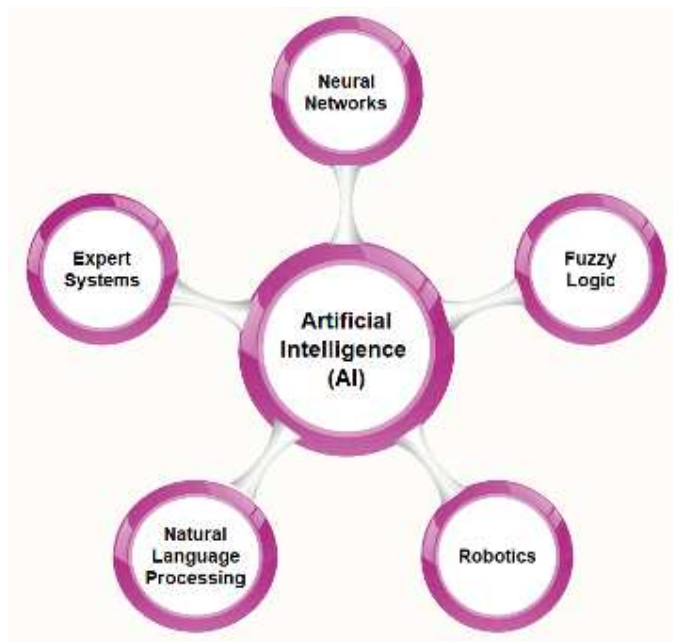


Figure 3 AI tools.

## Defining Generative AI

To understand generative artificial intelligence (GenAI), we first need to understand how the technology builds from each of the AI subcategories listed below.

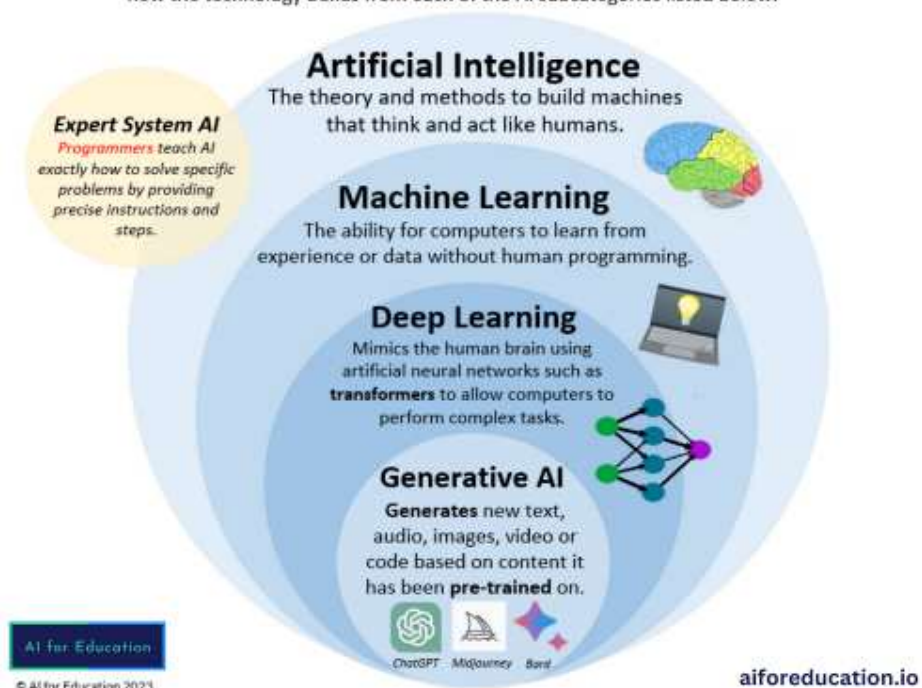


Figure 4 GenAI built on AI tools listed above [7].





Figure 5 Symbol of generative AI [8].

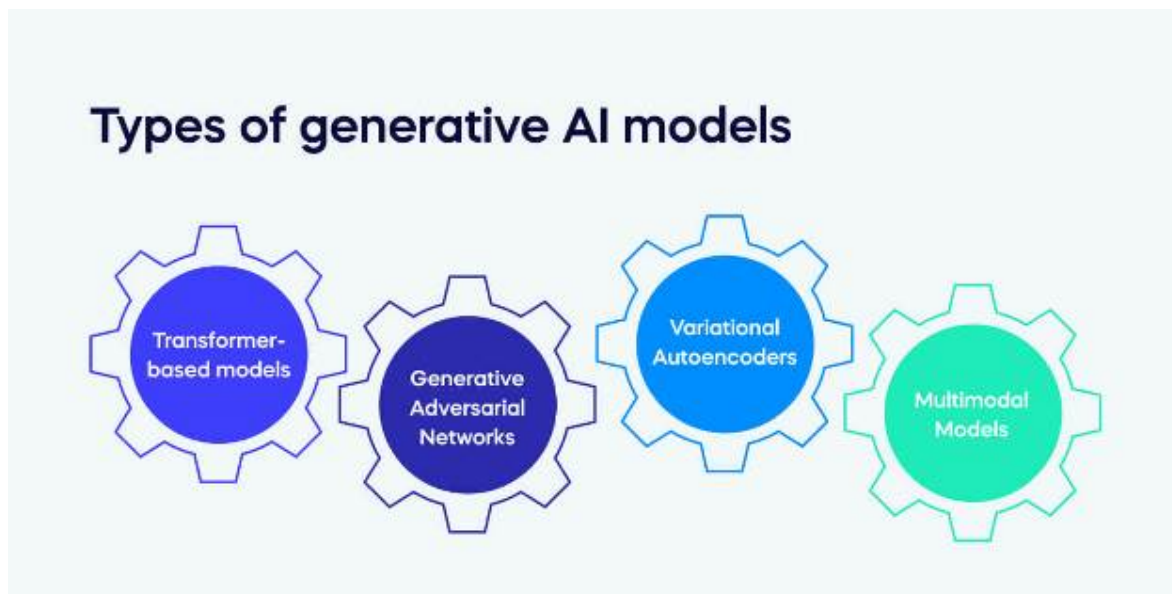


Figure 6 Different types of GenAI models [10].

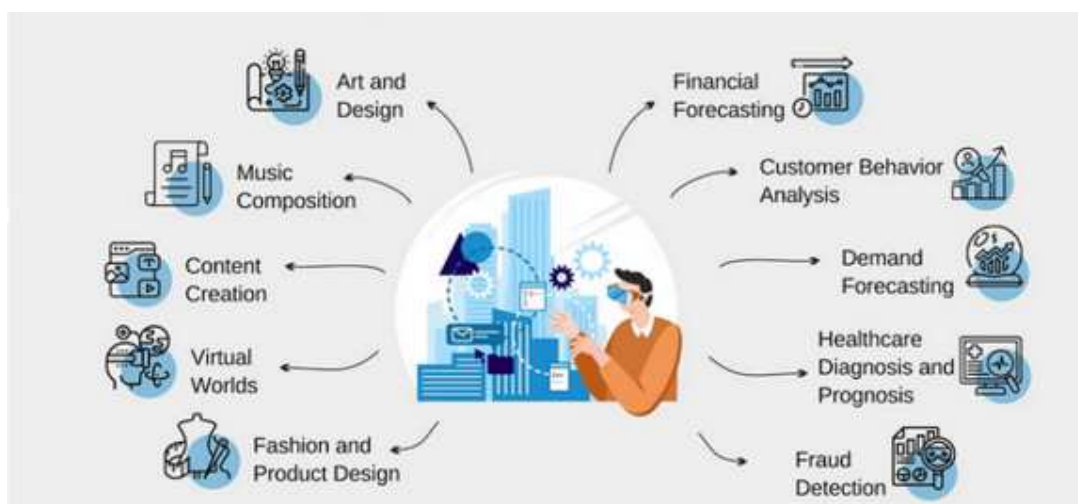


Figure 7 Some applications of GenAI [10].



**Figure 8 An image created using generative AI [14].**

